





Office of  
Transportation Technologies

## *OTT partnership commercializes ethanol*

Making cleaner, domestically sourced fuel more practical for the mass market

**E**thanol is a cleaner-burning, renewable fuel that can be produced from a number of domestic feedstocks, mostly crops such as corn and grains. Spurred by Federal incentives, ethanol is already blended at 10 percent concentrations into much of the gasoline Americans buy at the pump, helping to cut down on polluting emissions and making an immediate reduction in foreign oil imports. However, cost is an impediment to more widespread use of the fuel, both as an additive and in higher 85 percent concentrations, and is keeping Americans from gaining the substantial environmental and energy security benefits that replacement of large volumes of gasoline with ethanol could offer.

A private-/ public- sector partnership led by Amoco Corporation and the Office of Transportation Technologies (OTT) recently proved out a new process for producing ethanol from cellulosic materials, opening up a new world of low-cost feedstock possibilities, as well as allowing higher yields from traditional feedstocks by converting the fibrous parts of the plant. SWAN Biomass, an Amoco/Stone & Webster partnership, is planning to commercialize the process, making this new science available to ethanol producers nationwide.

OTT provides “missing pieces” in innovative process. According to Bob Walker, President of SWAN Biomass, Amoco became interested in developing alternatives to imported oil as a result of the oil crises of the 1970s, and began investigating and investing in the development of a number of candidate fuels. Because of its nearly limitless domestic renewability, ethanol was seen as having significant potential.

Amoco put together a process design, and invested in R&D efforts to develop process components, augmenting their own efforts by partnering with other innovative companies to acquire specific technologies.



*Secretary of Energy, Hazel O'Leary, pours corn fiber feedstock into the PDU hopper at the beginning of the biomass-to-ethanol process.*

By the early 1990s, they had identified three missing pieces that needed to be addressed—an effective pretreatment for cellulose activation, a low-cost enzyme to convert the cellulose activated in pretreatment to sugars, and an organism with the ability to convert both C-5 and C-6 sugars.

In 1991, Amoco officially began coordinating its R&D with that sponsored by OTT at the National Renewable Energy Laboratory (NREL) through the formation of a Cooperative Research & Development

Agreement (CRADA). CRADAs have a newly developed, streamlined format that allows the private and public sector to work together more efficiently. Under OTT finding, NREL was developing a process called simultaneous saccharification/fermentation, which combines two main conversion steps into one, decreasing production time and increasing yields. This process became the platform on which the team optimized its ongoing ethanol process development efforts.

By the next year, OTT and Amoco began jointly funding a genetic engineering and process R&D program at Purdue University. That work produced a genetically-engineered yeast robust enough to meet large-scale industrial ethanol production requirements.

As part of the CRADA, both partners invested in research associated with a Process Development Unit (PDU) to be built at NREL. This production scale facility is flexible and highly instrumented, allowing new biomass-to-ethanol technologies to be proved out beyond laboratory scale. The partners made extensive use of the new facility to refine and scale up the technology, demonstrating the commercial-scale effectiveness of their proprietary enzymes and yeasts, as well as individual process breakthroughs such as an aggressive pretreatment that activates tough lignocellulosic polymers. These and other efficiencies will help ethanol producers manufacture ethanol in the 60-80¢ per gallon range.

In early 1996, the PDU completed two successful full-scale, six-week runs to prove out the efficacy of the new cellulosic biomass-to-ethanol process, using corn fiber as a feedstock. With this milestone, the CRADA will accelerate into the final demonstration phase.

Recently, Amoco entered a joint venture with Stone & Webster Engineering to create a company capable of building or retrofitting ethanol plants based on the new technology. The new company, SWAN Biomass, has identified a number of multi-million dollar opportunities that it estimates could cumulatively increase

the availability and use of cost-effective ethanol by some 1000 percent or more in the long term. It is believed that this will help accelerate innovation and infrastructure around ethanol-fueled vehicles, helping OTT meet its energy security and environmental goals.

*More ethanol means increased energy security.* Increasing ethanol use from its current levels of about 1.5 billion gallons to 20 billion gallons, possible through application of this new technology, could provide a substantial reduction in American reliance on foreign oil. It also would serve to remove millions of tons of carbon monoxide and hydrocarbon emissions from the air, as well as to create tens of thousands of new jobs in diverse sectors including agribusiness, engineering, fuels production, plant construction and more.

The SWAN process allows the use of a wide variety of feedstocks, including yard waste, forestry wastes and waste paper, as well as corn and grains. This flexibility allows producers to switch back and forth among feedstocks, utilizing the most cost-effective available at the particular time. It also means a more geographically diverse use of ethanol, making the fuel cost-effective even in areas well outside of the farm belt.

In addition, ethanol facilities might also play a role in helping local communities solve waste problems, keeping many types of solid wastes out of landfills. SWAN is currently working with a community in California to convert its rice straw disposal problem into a clean fuel opportunity.

*A mutually successful partnership.* OTT's charter calls for the office to work with industry to commercialize the technologies that will help America boost its energy security and improve the quality of its air; and biomass-to-energy efforts are a major component of that goal. OTT continues to form additional partnerships with other innovative companies, working to help move promising research from the lab to the

marketplace, encouraging the construction of additional commercial biomass facilities, and making available the state-of-the-art PDU at NREL to all parties interested in proving out their technologies on a commercial scale.

According to SWAN President Bob Walker, Amoco has invested tens of millions of dollars in its ethanol technology programs, and although OTT's financial involvement is small in comparison, it was vital to their ultimate success.

"Although the private sector and the government may seem very different from a cultural standpoint, partnerships with the government can achieve results better than either partner could accomplish alone," Walker said. "It really takes patient money for fundamental new science to come to a point where it is viable commercially, and I think the trend now in the private sector is for a shorter-term focus. The government is the one that's taking the risk and bringing in that longer-term outlook. If not for the vision and tenacity of OTT, the U.S. would not have been able to develop viable alternative fuels in time to meet the objectives set by Congress in the Energy Policy Act of 1992."



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